UNIVERSITY OF CALIFORNIA AT BERKELEY

Physics 112 – Lec. 1 (Reinsch)

Fall 2003

FIRST MIDTERM EXAMINATION

Please try to do all your work on the front and back pages of this exam. If that is not enough space, you may attach additional paper. Please write your name on all pages.

On problems that call for numerical answers, it is highly recommended that you work with symbols until the very end and then plug in numbers. The longer you work with symbols, the more partial credit you will get, in case you get the answer wrong.
Please circle your final answer.

NAME:

STUDENT ID NUMBER:

SIGNATURE:

	SCORE
1. 25 points	
2. 25 points	
3. 25 points	
4. 25 points	
Total: 100 points	

Problem 1 [25 points]

Light is called red if its wavelength λ is in the range from λ_{R1} to λ_{R2}. The range for blue light is from λ_{B1} to λ_{B2}. Let ΔA denote a small area on the inner surface of an ideal blackbody cavity at temperature τ.

(a) What is the total blue power radiated by the area ΔA? Your answer should be left as an integral over the frequency ω. You do not have to evaluate the integral or make it dimensionless by scaling out constants.

(b) Approximate the integral in part (a) by assuming the integrand is equal to a constant: the value of the integrand at the midpoint of the interval of integration.

(c) For this part of the problem, we will use the following numbers.
λ_{R1} = 650 nm, λ_{R2} = 700 nm, λ_{B1} = 450 nm, λ_{B2} = 500 nm, $\Delta A = 1.0\times10^{-4}$ m^2
Evaluate the approximate red and blue powers for T = 300K. Repeat for T = 1000K (As a check on your work, note that 1000K is "red hot.")

Problem 2 [25 points]
The energy levels of a system are indexed by two positive integers m and n. The energies are $\varepsilon(m, n) = a\, m^2 + b\, n^3$, where a and b are positive constants. The multiplicities are $g(m, n) = m\, n^2$.

(a) Find the partition function Z, based on its definition as a sum.
(b) Show that the partition function Z is exactly equal to the product of two infinite sums. Each of the two sums is a sum over one index.
(c) For values of τ large compared to a and b, the sums can be approximated by integrals. The integrals are elementary and can be done by a change of variables. Find the result for Z.
(d) Based on the result from part (c), find the heat capacity.

Problem 3 [25 points]
[This problem is a homework problem from the textbook. You must show your work, not just quote the result.] Consider a dielectric solid with a Debye temperature equal to 100K and with 10^{22} atoms cm^{-3}. Estimate the temperature at which the photon contribution to the heat capacity would be equal to the phonon contribution at 1K.

Problem 4 [25 points]
A machine is constructed that flips 10,000 coins and displays the number of heads minus the number of tails every time the button is pushed.

(a) The machine is run a large number of times, and the results are plotted in a histogram. The horizontal axis is labeled "the number displayed by the machine." Find the "Full Width at Half Maximum" (FWHM) of this distribution.

(b) A super-machine is constructed. It contains 100 of the original machines. At the push of a button, all 100 machines are run, and the average of their displays is displayed. The super-machine is run a large number of times, and a histogram is created as in part (a). What is the FWHM for this plot?